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Vegetarianism and veganism: not only benefits but also gaps. A review

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Summary. *Background and aim of the work.* The main Food Choice Motives (FCMs) of vegetarianism and veganism are supported by ethical, health, ecological and pleasure motivations, but also family and cultural traditions play a definite role. A better health achievement is usually the first goal of turning vegetarians, on the reports that ischemic heart, circulatory and cerebrovascular diseases, type 2 diabetes, and some cancer were significantly lower in vegetarians and vegans than in omnivores. In this review, we investigate the main reasons that lead to the choice of an increasingly common lifestyle, such as vegetarianism and veganism and the pros & cons of this choice. *Methods.* We reviewed studies focused on vegetarian and vegan diets, and included articles published between 1975 and 2015. We searched Pubmed/Medline using the terms "vegetarianism", "veganism", "benefits" and "diseases", alone or combined. This review aims at describing vegetarian and vegan diets, discussing current knowledge about motivations for pursuing this diet, clinical benefits and limitations. *Results.* Vegetarian and vegan diets are low in n-3 PUFA, proteins, calcium, zinc, iron, vitamins B12 and D. *Conclusions.* Different guidelines for vegetarian and especially vegan diets have been settled based on the need to fortify foods with molecules that are reduced or missing in these diets.

Key words: vegetarian, vegan, benefits, diseases

Introduction

The Vegetarian Society coined the term 'vegetarian' in the mid nineteenth century, and this is used to cover a range of dietary choices that avoid some or all foods with animal origins (1-2). Actually, the vegetarian restrictive form is spreading the veganism. Studies of vegetarians have identified in addition to religious reasons, a variety of non-religious motivations for adopting a meat-free diet (3). Personal health and animal cruelty figure high on the list of the motivations (2,4), while disgust or repugnance eating flesh (5-7) association with patriarchy (8), food beliefs and peer or family influences (4) are also noted. Hoek A.C. *et al.* (2) note the emergence of a 'vegetarian-oriented consumerism' that addresses ethical and environmental concerns, while Allen Fox M. (9) suggests that a vegetarian economy contributes to 'ecosystem health' by reducing the impact on the environment and economies of pollution, intensive farming and land degradation by grazing, affecting both developed and less-developed countries. Awareness of their contribution to the future of the planet can also support good psychological health among vegetarians (10). Jabs J. *et al.* (11) examined life-course trajectories and the impact of life events on vegetarians' food choices, finding different patterns of adoption between two main categories: health and ethical vegetarians, which may graduate from semi- or ovo-lacto-vegetarianisms to vegan diets over time.

Health vegetarians choose to avoid meat in order to derive certain health benefits or lose weight (10-13) not eating red meat, limiting their consumption of flesh to fish, or selecting only organic products

(2,14-15). Instead ethical vegetarians consider meat avoidance as a moral imperative not to harm animals for food or other reasons (16-17). Health vegetarians tended to make gradual 'trial adoptions' of food choices, while 'ethical vegetarians' made more sudden changes in their diet to support beliefs such as animal welfare, and create consistency in their lives (18). In fact, one of the most common reasons for abandoning meat is precisely to prevent cruelty to animals (6,19) and vegetarians held negative explicit and implicit attitudes toward meat associating it with disgust, the killing of animals, and cruelty (20).

Despite the popular opinion that vegetarianism and veganism are healthy options, there are some precautions to be taken to ensure that the diet is well balanced.

Methods

We reviewed studies focused on vegetarian and vegan diets, and included articles published between 1975 and 2015. We searched Pubmed/Medline using the terms "vegetarianism", "veganism", "benefits" and "diseases", alone or combined. This review aims at describing vegetarian and vegan diets, discussing current knowledge about motivations for pursuing this diet, clinical benefits and limitations

Types of vegetarianism and veganism

There are different ideologies about vegetarian people base their lifestyle, sharing the exclusion of meat in their diet. Then it is possible to distinguish different typologies of vegetarianism which features are summarized in Table 1.

Finally, three different types as core categories characterize veganism: Conformed Vegans, Organized Vegans, and Individualistic Vegans (21). *Conformed Vegans* socialized mainly with other vegetarian people often in groups and wished to share the main attitudes and behaviours of the group. Conformed Vegans were not convinced in their veganism and the informants

Table 1. Types and characteristics of vegetarian diets.

Vegetarian diets	Allowed food	Excluded food
Strict veganism and *Su vegetarianism*	Vegetables Fishes	Animal products (eggs, dairy, beeswax and honey, leather products and goose-fat shoe polish) Garlic, onion, spring onion, scallions and leeks Products that may contain animal ingredients not included in their labels or which use animal products in their manufacturing, e.g. cheeses that use animal rennet (enzymes from animal stomach lining), gelatine (from animal skin, bones and connective tissue) Some sugars that are whitened with bone char (e.g. cane sugar but not beet sugar)
Raw veganism	Fresh and uncooked fruit Nuts Seeds Vegetables	All animal products (eggs, dairy, honey) Cooked foods
Fruitarianism	Fruit, nuts, seeds, and other vegetables that can be gathered without harming the plant	Animal products (eggs, dairy, honey). Fruit, nuts, seeds, and other vegetables that can be gathered harming the plant
Lacto-ovo-vegetarianism	Eggs and dairy products	Animal meat
Ovo-vegetarianism	Eggs	Dairy products
Lacto-vegetarianism	Dairy products	Animal products (eggs, beeswax and honey, leather products and goose-fat shoe polish)
Pesco-vegetarianism	Fish	Animal products (eggs, dairy, beeswax and honey, leather products and goose-fat shoe polish)

reported that most often they eventually dropped off. However, sometimes the Conformed Vegans became more consistent vegans, such as Organized or *Individualistic Vegans*, and the latter was the case of one of the informants and described by the others. *Organized Vegans* were convinced in their veganism and anchored in vegan ideology. Their ideas were characterized by animal ethics, equality, solidarity, and non-parliamentary political points of view. They believed that animals were equal to humans and protested against the exploitation of animals. They wanted public attention and were very engaged in taking part in demonstrations, distributing vegan information, participating in campaigns against companies such as McDonald's and participating in public debates with enthusiasm and initiated boycotts of various products.

Motivations

People not only define vegetarianism in vastly different ways, but their motivations for pursuing a vegetarian diet also cover a wide territory. Vegetarianism is not only a cognitive or expressive response to food, but it is also an embodied practice that can act as a cue to identity (22-24).

Most vegetarians made a decision to convert from a meat-eating diet (25) for a range of reasons, including concern about animal welfare, religious and cultural beliefs, the ethics of raising and slaughtering non-human animals (7, 11, 26-27) and personal health (6, 26-27). One's motivations for being vegetarian, whether primarily for reasons of ethics or health, have a profound impact on one's process of becoming vegetarian, dietary behaviour, and ideology (6, 11). *Health vegetarians* adopted their vegetarian diet out of concern for potential disease, and focused primarily on the various benefits, control of weight (10-13) and barriers to changing their diet. The health ideology (HI) reflected a relationship between the values that stress the maintenance and conservation of the existing social order, i.e. tradition, conformity and security, and FCMs of eating healthily and in a manner conducive to weight control. Choosing food in a health- or weight-conscious fashion is undoubtedly an act of conforming to current societal norms and pressure: within the current western cultural context, thinness and health have come to represent virtue, success and status, and those who do not conform are easily considered as modern-day sinners (28-29). Health vegetarians tended to gradually eliminate meat from their diets, and were relatively less likely to transition toward veganism. Instead, as described by Ruby M.B. (30), *ethical vegetarians* adopted their vegetarian diet for reasons of animal welfare, focusing primarily on moral considerations. They tended to adopt their diets abruptly, associating meat with disgust and emotional distress, and reducing this distress by creating consistency between their diet and their beliefs about animal welfare.

Furthermore, ethical vegetarians often conceptualize their dietary choices in broader terms, explicitly connecting it to larger philosophical frameworks and reacting to meat consumption with more pronounced feelings of disgust. Cultural norm sand culturally shaped emotions strongly influence an individual's sense of the moral and immoral (31), with many collectivistic cultures, such as India, displaying a stronger relationship between feelings of disgust and morality judgments (32).

Diseases and deficiencies

Globally increasing prevalence of Non-communicable diseases (NCDs) is associated with ageing, rapid unplanned urbanization and the globalization of unhealthy lifestyles (33). Unhealthy lifestyles include unhealthy diets, physical inactivity, exposure to tobacco, smoke and harmful use of alcohol. In particular, globalization of unhealthy diets may result in raised blood pressure, increased serum glucose and lipids, overweight and obesity. Becoming a vegetarian has become increasingly popular over the past decade, with many people turning to vegetarianism in an attempt to achieve better health. In fact compared with omnivores, all-cause mortality and immortality from NCDs such as ischemic heart disease, circulatory and cerebrovascular diseases, type 2 diabetes and all the cancer incidences, except breast cancer, were significantly lower in vegetarians than in omnivores. A vegan diet appears to be useful for increasing the intake of protective nutrients (fibre, magnesium, folic acid, vitamins C and

E, iron) and phytochemicals and for minimizing the intake of dietary factors implicated in several chronic diseases (34-35). These nutritional differences may explain some of the health advantages of those following a varied, balanced vegetarian diet (36).

In general, compared with an omnivorous diet, vegetarian and vegan diets are rich in fibre, magnesium, Fe^{3+}, folic acid, vitamins C and E, n-6 polyunsaturated fatty acid (PUFA), carotenoids, flavonoids, other phytochemicals and antioxidants. However, these diets are low in total fat, n-3 PUFA, calcium, iodine, zinc, $Fe^{2+,}$ vitamins B12 and D (36). Increasingly important are the nutritional programs, such as the Special Supplemental Nutrition Program for Women, Infants, and Children, which is a federal grant program that serves pregnant, postpartum, and breastfeeding women, infants and children up to age 5 years who are documented as being at nutritional risk. In particular, this program provides vouchers to purchase some foods suitable for vegetarians including infant formula, iron-fortified infant cereal, vitamin C–rich fruit or vegetable juice, carrots, cow's milk, cheese, eggs, iron-fortified ready-to eat cereal, dried beans or peas, and peanut butter. Recent changes to this program promote the purchase of whole-grain breads and cereals, allow the substitution of canned beans for dried beans, and provide vouchers for purchasing fruits and vegetables. Soy-based beverages and calcium-set tofu that meet specifications can be substituted for cow's milk for women and for children with medical documentation.

There are also different points of view regarding the nutritional status of vegan children. Several studies (37-39) have shown that malnutrition and poor growth, and in a few cases death, have been reported among infants and children fed very restricted vegan and macrobiotic diets. Then, these diets are not recommended for children. Sanders T. (40) has supported in part this theory, noting through his studies that the diets of vegan children are typically lower in energy than those of omnivores, and vegan children are frequently smaller and lighter than other children are. Nevertheless, Sanders T. and Manning J. (41) found that growth and development of 20 vegan children were within the normal range, although the children were all exceptionally lean. Furthermore, the vegan children in this study had slower rates of growth, especially up to 5 years of age, but catch-up growth had occurred by 10 years of age. Table 2 shows principal nutrients, sources and deficiencies about vegetarian and vegan diets.

Several studies have analyzed the association between vegetarian and vegan diets and some diseases, such as osteoporosis and eating disorders.

Bone density

Studies examining the association between vegetarianism and bone density have found conflicting results. Several studies conducted prior to 1990 (79-82) found bone mineral density to be higher among vegetarians than meat-eaters, but confounding lifestyle factors were apparent for many of these. Subsequent studies have shown no difference in bone mineral density between meat-eaters and vegetarians (83-85). Dyett P.A. *et al.* (86) have understood that the possible connection between a vegan lifestyle, low Bone Mineral Density (BMD), lower intake of calcium and the development of osteoporosis has important societal as well as medical implications.

Eating disorders

Choosing a vegetarian diet for the purposes of weight control might play a role in the aetiology of disordered eating. In particular, two studies have attempted to determine causality in the relationships between vegetarianism and eating disorders via retrospective chart reviews of patients seeking treatment for eating disorders. In one study, out of 200 patients receiving treatment for anorexia nervosa, just under half were considered vegetarian (87). In another, out of 116 individuals with anorexia, just over half of the patients claimed a vegetarian diet (88) and the majority adopted vegetarian diet during or after the development of the eating disorder. The adoption of a vegetarian diet after the onset of a disorder may indicate that rather than being a causal factor, a vegetarian diet may play a maintenance role in eating disorders pathology. Thus, it may be that it is not vegetarianism leads to disordered eating, but rather a partial restriction of meat (semi-vegetarian) for the purposes of weight control, possibly in combination with other risk factors related to the development of eating disorders. Full vegetarianism may, as has been noted, play more

Table 2. Principal nutrients, sources and deficiencies of vegetarian and vegan diets.

Nutrient	Source	References	Deficiency
Omega 3 Fatty Acids	• Fish • Eggs • Algae	Rosell MS *et al* (2005) (42)	Eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), which are fatty acids essential for cardiovascular health as well as eye and brain development
		Geppert J *et al*. (2005) (43)	Pregnant and lactating women may benefit from DHA-rich microalgae. DHA supplements should be taken with caution: although they can lower plasma triacylglycerol, they can raise total and LDL cholesterol, causing excessively prolonged bleeding times, and impair immune responses
		Institute of Medicine, Food and Nutrition Board (2002) (44)	Accordingly, the Dietary Reference Intakes recommend intakes of 1.6 and 1.1 g ALA per day, for men and women, respectively. Vegetarians who consume little if any DHA and EPA and thus may need additional ALA for conversion to DHA and EPA
Protein	• Animal meats • Algae • Legumes • Soy and derivates • Seitan	Young VR and Pellett PL (1985) (45) Institute of Medicine (2003) (46)	Compared with animal proteins, vegetal proteins do not contain high concentrations of the indispensable amino acids and are not used with the same efficiency
		Kniskern MA and Johnston CS (2011) (47)	Dietary proteins adequacy is an important health consideration for vegetarians. It has been suggested that the protein Dietary Reference Intakes (DRI) for vegetarians consuming less than the predicted amounts of animal protein (45–50% of total protein) may need to be adjusted to account for decreased protein bioavailability. Vegetarians with low intakes of animal proteins may need to consume an additional 12 to 15 g of protein daily, which equates to about 1.0 g/kg of body weight
Iron	• Animal meats • Cereal • Grain • Nut • Seed • Vegetables • Fruits • Dairy • Egg • Miso • Tempeh	Hunt JR (2002) (48)	A plant-based diet alters the distribution of dietary iron between the efficiently absorbed heme form that is approximately 40% of the iron in meat, poultry and fish, and the less well-absorbed non-heme form present in all foods
		Ma G *et al*. (2005) (49) Siener R *et al*. (2006) (50) Hallberg L and Rossander L (1982) (51) Lynch SR *et al*. (1985) (52) Coudray C *et al*. (1997) (53)	Bioavailability and absorption of non-heme iron may be inhibited by certain dietary constituents that are abundant in some vegetarian diets, such as oxalates in vegetables and phytates in cereals and legumes (49-50), polyphenols, such as tannic and chlorogenic acids, in tea, coffee, red wines, (51) and possibly soy protein (52), while fibre only slightly inhibits iron absorption (53)
		Institute of Medicine, Food and Nutrition Board (2001) (54)	Iron intakes for vegetarians are 1.8 times those of no vegetarians
Calcium	• Egg • Bock choy • Broccoli • Collards and kale • Tofu • Cow's milk • Sesame seed • Almonds • Dried beans	Messina V. *et al*. (2004) (55)	Calcium intakes of lacto-ovo-vegetarians are similar to, or higher than, those of non-vegetarians, whereas intakes of vegans tend to be lower than both groups and may fall below recommended intakes
		Appleby PN *et al*. (2007) (56)	In the Oxford component of the European Prospective Investigation into Cancer and Nutrition (EPIC-Oxford) study, the risk of bone fracture was similar for lacto-ovo-vegetarians and meat eaters, whereas vegans had a 30% higher risk of fracture possibly due to their considerably lower mean calcium intake
		Weaver C. *et al*. (1999) (57)	The ratio of dietary calcium to protein is a better predictor of bone health than calcium intake alone; typically, this ratio is high in lacto-ovo-vegetarian diets and favours bone health, whereas vegans have a ratio of calcium to protein that is similar to or lower than that of non-vegetarians
		Weaver C. *et al*. (1999) (57) Messina V *et al*. (2003) (58)	Many vegans may find it is easier to meet their calcium needs if calcium-fortified foods or dietary supplements are utilized
		Zhao Y *et al*. (2005) (59)	The bioavailability of calcium from soymilk fortified with calcium carbonate is equivalent to cow's milk although limited research has shown that calcium availability is substantially less when three-calcium phosphate is used to fortify the soy beverage

(continued)

Zinc	• Soy products • Legumes • Grains • Cheese • Nuts	Ball MJ and Bartlett MA (1999) (60) Janelle KC and Barr SI (1995) (61)	Was find zinc intakes of vegetarians significantly below recommendations. The lower bioavailability of zinc from vegetarian diets is mainly due to the higher phytic acid content of these diets, which binds zinc and thereby decreases its bioavailability
Vitamin B12	• Seafood • Animal meats • Eggs • Liver	Stabler SP and Allen R (2004) (62) Hung CJ *et al*. (2002) (63) Yajnik CS *et al*. (2006) (64) Young VR and Pellett PL (1994) (65)	Cobalamin deficiency constitutes a worldwide problem (62) and is currently regarded as the principal causal factor of in vegetarian populations' hyperhomocysteinemia (63-64), because vitamin B12, as also lower concentrations of protein and essential amino acids, especially lysine and methionine (65), is almost totally absent from plant foods
		Herrmann W *et al*. (2001) (66)	Vegetarian diets are typically rich in folacin, which may mask the haematological symptoms of vitamin B12 deficiency, so that vitamin B12 deficiency may go undetected until after neurological signs and symptoms may be manifest
		Li D. *et al*. (2000) (67)	Serum vitamin B12 concentration decreased progressively from the high-meat-eaters group to the moderate-meat-eaters group, ovo-lacto-vegetarians and vegans
		Watanabe F (2007) (68) Yamada S *et al*. (1996) (69) Herbert V (1988) (70) Koyyalamudi SR *et al*. (2009) (71)	For vegans, vitamin B12 must be obtained from seaweed (68-70), plants and edible fungi (such as mushrooms) on farms or in the wild, which may be contaminated from bacteria in the soil (71) and regular use of vitamin B12-fortified foods, such as fortified soy and rice beverages, some breakfast cereals and meat analogues
Vitamin D	• Cow's milk • Soymilk • Rice milk • Orange juice • Cereals • Margarines • Rocket salad	Messina V. *et al.* (2004) (55) Dunn-Emke SR *et al*. (2005) (72) Parsons TJ *et al*. (1997) (73)	Low vitamin D intakes (72), low serum 25-hydroxyvitamin D levels (55) and reduced bone mass (73) have been reported in some vegan and macrobiotic groups who did not use vitamin D supplements or fortified foods
		Davey GK *et al*. (2003) (34)	In the EPIC-Oxford study, vegans have shown the lowest mean intake of vitamin D (0.88 lg/d), a value one-fourth the mean intake of omnivores
		Trang HM *et al*. (1998) (74)	Another matter of concern for vegans is that Ergocalciferol, the form of vitamin D acceptable to vegans, is substantially less bioavailable than the animal-derived vitamin D3
		Outila T.A. *et al.* (2000) (75)	In Finland, the dietary intake of vitamin D in vegans was insufficient to maintain serum 25-hydroxyvitamin D and parathyroid hormone concentrations within normal ranges in the winter, which appeared to have a negative effect on long-term BMD
Iodine	• Sea fish • Salt • Cow's milk • Egg • Cereals • Animal meats • Legumes	Messina V. *et al*. (2004) (55) Krajcovicova M *et al*. (2003) (76)	Vegans who do not consume key sources of iodine, such as iodized salt or sea vegetables, may be at risk for iodine deficiency, because plant-based diets are typically low in iodine
		Leung A.M. *et al. (2011)* (77)	Iodine content of a Swedish vegan diet was approximately four times lower than a mixed diet
		Lightowler H.J. *et al.* (1996) (78)	Iodine content of vegan diet was lower than other diets

of a role in the maintenance of the disorder. Timko A. *et al*. (89) in their first study have demonstrated that vegans and true vegetarians had significantly lower levels of restraint, external eating, hedonic hunger and greater levels of acceptance in relation to food in comparison to semi-vegetarians. This highlights previously unacknowledged positive aspects of adhering to a completely meat or animal product free diet. With a second study, differences between semi-vegetarians and omnivores were explored in more depth, specifically disordered eating, but differences between the groups were few. Taken together, these two studies do indicate clearly that semi vegetarians are at the most risk for disordered eating patterns. The food environment in the United States is considered to be 'obesogenic', which means it has appealing, inexpensive, high calorie food available rather easily (90), and eating a healthy lower calorie diet is more difficult because it is more expensive and not as readily available (91). Due to the current food environment, semi-vegetarians may

eat a diet low in meat products in an attempt to control their weight and type of food consumed. Vegans appear to have the healthiest attitudes towards food, closely followed by vegetarians. Non-vegetarians more closely resemble semi vegetarians, though as noted the former has more maladaptive attitudes.

Recommendations for a well-balanced diet

For healthy individuals, a well-balanced vegetarian or vegan diet can provide adequate amounts of all of the nutrients required by the body throughout the lifecycle. However, as written by Craig W.J. (92) and Panebianco S.M. (93), more attention and careful dietary planning may be required for specific vulnerable subgroups in the population and, just following a few simple rules, the diet will be fully healthy and safe (Table 3).

Table 3 . Reviews about recommendations for balanced diets.

References	Recommendations
Craig WJ (2009) (92)	For an adequate vitamin D status, vegans should regularly consume vitamin D–fortified foods such as soymilk, rice milk, orange juice, breakfast cereals, and margarines that are fortified with vitamin D. Where fortified foods are unavailable, a daily supplement of 5–10 μg vitamin D would be necessary
Panebianco SM (2007) (93)	It is recommended that vegans consume foods that are fortified with the long-chain n–3 fatty acid DHA, such as some soymilks and cereal bars. DHA-rich microalgae supplements and omega-3 fatty acid supplementation from reliable DHA/EPA sources are useful for pregnant and lactating women, whom increased requirements of long-chain n–3 fatty acids. Furthermore, at least two or three servings of fat-rich plant foods each day, including nuts and seeds, are a primary source of polyunsaturated fats (seeds) and monounsaturated fats (nuts)
Zhao Y *et al.* (2005) (59) Andon MB *et al*. (1996) (94)	Calcium supplementation is highly recommended for those who follow a diet free of dairy consumption. The bioavailability of the calcium carbonate in the soy beverages and the calcium citrate malate in apple or orange juice is similar to that of the calcium in milk. Calcium-set tofu, fortified fruit juices and cow's milk provide good calcium bioavailability, while fortified soymilk, sesame seeds, almonds and most legumes, provide calcium with moderate bioavailability
Allen LH (2009) (9) Krebs NF (1998) (95)	Zinc bioavailability and amounts tend to be lower in plant foods compared to animal sources. Because of the high phytate content of a typical vegan diet, it is important that a vegan consume foods that are rich in zinc, such as whole grains, legumes and soy products, to provide a sufficient zinc intake. Benefit could also be obtained by vegans consuming fortified ready-to-eat cereals and other zinc-fortified foods, especially for vegan infants with low intake of zinc
Craig WJ (2009) (92)	To avoid B-12 deficiency, vegans should regularly consume vitamin B-12–fortified foods, such as fortified soy and rice beverages, certain breakfast cereals and meat analogues or take a daily vitamin B-12 supplement. Also fermented soy products, leafy vegetables, and seaweed cannot be considered a reliable source of active vitamin B-12
Panebianco SM (2007) (93) Lightowler HJ and Davies GJ. (1998) (96)	Vegans who avoid iodized salt may be at risk for iodine deficiency. In addition, foods containing natural goitrogens such as soybeans, cruciferous vegetables, sweet potatoes, millet, and raw flaxseed may reduce iodine uptake. So it is recommended to use iodized salt, in the right daily amounts
Phillips F. (2005) (97)	Careful dietary planning is needed for infants who are weaned onto vegan diets to ensure that adequate energy, essential fatty acids, protein, calcium and foods fortified with vitamin B12 (or supplements), are included. In fact, restrictive dietary patterns, such as some extreme macrobiotic diets, have been found to lead to poor growth and malnutrition; such diets are not recommended for infants and children. Particular attention to dietary requirements for vitamins and minerals is needed during pregnancy and lactation. Guidelines on what to eat during pregnancy and lactation are essentially the same for vegetarians as for meat-eaters, but women on restricted diets may need to consume supplements or fortified food in order to meet these
Phillips F. (2005) (97)	For female vegetarian athletes to eat sufficient iron-containing foods and foods that promote absorption of iron. A poorly planned vegetarian diet can have an adverse effect on physical performance and long-term health

Benefits

With a good planning and careful attention, vegetarian and vegan diets can include in their diets all essential nutrients. The degree of the beneficial effects of their diets often appears to be correlated with the number of years of the vegetarian or vegan diet, sex, smoking, alcohol consumption, body mass index, social class and physical activity level. According to the evidence criteria of the World Health Organization and Food and Agriculture Organization (WHO/FAO), cancer risk reduction associated with a high intake of fruit and vegetables was assessed as probable or possible, risk of cardiovascular disease reduction as convincing, whereas lower risk of osteoporosis was assessed as probable (98). Several studies have suggested that dietary factors have an important influence on longevity and the risk of a number of chronic diseases (35). In general, it has been observed that vegetarians had lower risks of obesity, hypertension, cardiovascular diseases, diabetes, arthritis, cancers (especially colon and prostate cancer) and fatal ischemic heart disease, thanks to protective substances found in fruits, vegetables, legumes, seaweed, seeds, whole grains, vegetable oils and other plant-based foods. In contrast, meat products contain no dietary fibre and often contain substantial quantities of cholesterol and saturated fats that raise LDL-cholesterol concentrations. Meats do not contain significant amounts of phytochemicals, widely present in plant-based foods, which may have protective effects and work via a range of mechanisms. Red and processed meat intake has been positively associated with cardiovascular diseases, type 2 diabetes mellitus and certain cancers through epidemiological studies (99-100). Moreover, there is some evidence that the process of heating and cooking meats, particularly if there is any burning, may form compounds such as polycyclic aromatic hydrocarbons and heterocyclic amines that are carcinogenic.

The evidence for the health benefits of plant-based and vegetarian diets is derived primarily from epidemiologic studies, considering Hazard ratios (HRs), 95% Confidence Intervals (CIs) and Multivariate Relative Risks (RRs) for the risk of specific diseases, often starting from studies based on the analysis and comparison of questionnaires (Table 4).

Table 4. Benefits of vegetarianism and veganism for risk prevention to develop metabolic, cardiovascular, neurodegenerative and oncologic diseases.

Cardiovascular diseases	
Djoussé L *et al.* (2004) (101)	A higher consumption of fruit and vegetables (rich in fibre, folic acid, antioxidants and phytochemicals) is inversely associated with lower blood cholesterol concentrations in women and men. Diets based on this food, such as vegetarianism and veganism, can benefit indirectly from this advantage
Bazzano LA *et al.* (2002) (102) Bazzano LA *et al.* (2003) (103)	A higher consumption of fruit and vegetables is inversely associated with a 27% lower stroke incidence, a 42% lower stroke mortality, a 24% lower ischemic heart disease mortality and a 27% lower cardiovascular disease mortality. Diets based on this food, such as vegetarianism and veganism, can benefit indirectly from this advantage
Kelly JH Jr and Sabate J (2006) (104) Mellen PB *et al.* (2008) (105)	A higher consumption of whole grains, soy, and nuts provides significant cardio protective effects in vegan
Hertog MGL *et al.* (1993) (106)	Dietary flavonoid intake is significantly inversely associated with mortality from coronary artery disease and inversely related incidence of myocardial infarction. The authors measured the content in various foods of the flavonoids quercetin, kaempferol, myricetin, apigenin and luteolin, and assessed the flavonoid intake of 805 men. The RR of coronary heart disease mortality in the highest versus the lowest tertile of flavonoid intake was 0.42 and after adjustment for several variables, the risk was 0.32
Key TJ *et al.* (2009) (107) American Dietetic Association & Dietitians of Canada (2003) (108)	Vegetarians and vegans have demonstrated lower serum cholesterol concentrations, lower body mass indices, lower incidence of diabetes and lower blood pressure than comparable non-vegetarians have. It has been observed that especially long-term consumption of a low-calorie low-protein vegetarian diet is associated with a decrease of these multiple cardiovascular risk factors
Appleby PN *et al.* (2002) (109)	Comparing hypertension, systolic and diastolic blood pressures in 11004 British men and women, divided in four diet groups (meat eaters, fish eaters, vegetarians and vegans), it was found that meat eaters had the highest values of systolic and diastolic blood pressures, whereas vegans the lowest values, as well lower prevalence of hypertension. All this probably because of differences in body mass index
Ferdowsian HR and Barnard ND (2009) (110)	Vegetarian and lacto-ovo-vegetarian diets are associated with reductions in LDL-C of about 10–15 %, vegan diets of approximately 15–25% and combination diets (vegetarian with added fibre, soya and nuts) of approximately 20–35%

(continued)

Key TJ *et al.* (1999) (111)	Mortality for Coronary heart disease was 32% higher in the non-vegetarians
Anholm AC (1975) (112) Ophir O. *et al.* (1983) (113)	Blood Pressure (BP) levels generally tend to be lower in individuals following self-selected vegetarian diets compared with non-vegetarians
Yang S.Y. *et al.* (2012) (114)	Vegetarian monks still had a low probability of CV risk in 10 years (6.1 %), whereas the omnivore men had a much higher probability (17.9 %). The vegetarians also had over thinner IMT compared to the omnivores dependent on duration of vegetarian diet, lower BMI, weight, systolic blood pressure and diastolic blood pressure. In addition, the levels of triglyceride, total cholesterol, HDL-Cholesterol, LDL-Cholesterol, ApoA1, ApoB, uric acid, albumin and g-glutamyl transferase were significantly reduced in vegetarians
Zhang HJ *et al.* (2013) (115)	Authors studied the vegetarian diet of the Buddhist monks that exclude all animal products as well as vegetables in the Allium family (onion, garlic, scallions and leeks) and contained soybean as their main source of dietary protein, while few ate eggs and milk. Vegetarian Buddhist monks had significantly lower levels of TC (total cholesterol), LDL-C (low-density lipoprotein cholesterol), triglycerides (TG) and apolipoprotein B (apoB) than omnivores (by 15 %, 17 %, 10 % and 14 %, respectively). So Buddhist monks had also a lower predicted probability of CHD, compared with omnivore men, thanks to a significantly lower cluster of CV risk factors (lipids, blood pressure, glucose metabolism and body mass index), despite lower socioeconomic status and less physical activity of Buddhist monks
Ischaemic Heart Disease (IHD)	
Snowdon D.A. *et al.* (1984) (116)	Within the Californian Adventist cohort were compared the rate of events in vegetarians and non-vegetarians and showed about a 50% increase in risk in those who ate meat. A subsequent re-analysis of the Californian Adventist data confirmed the importance of meat consumption as being associated with around a 50 % significant increase in the risk of fatal ischaemic heart disease in Adventists who ate beef more than twice a week. The same analysis, however, showed an important effect of nut consumption. The risk of fatal IHD in Adventists who ate nuts more than four times a week was just over half that in Adventists who never ate nuts (RR 0.59)
Burr M. and Butland B.K. (1988) (117)	Studying 10896 persons, including 4671 vegetarians and 6225 non-vegetarians., was observed that mortality from IHD was significantly lower in the vegetarians than in the non-vegetarians and in a subset of 300 subjects, serum cholesterol and body mass index were lower in the vegetarians
Thorogood M. *et al.* (1994) (118)	Investigated the health consequences of a vegetarian diet by examining the 12-year mortality of non-meat eaters and meat eating controls. Standardised mortality ratios for IHD were 0.51 for meat eaters and 0.28 for non-meat eaters. It was probably because vegetarians had lower blood pressure, low-density lipoprotein cholesterol concentration and lower proportions of arachidonate, eicosapentaenoate and docosahexaenoate in platelet phospholipid, whereas the phospholipid linoleate and antioxidant concentrations are higher. These factors lead to a reduced oxidation of low-density lipoprotein and a reduced tendency to both atherogenesis and thrombogenesis
Mann J.I. *et al.* (1997) (119)	Analysed the relation between IHD and body mass index (BMI), involving 10802 men and women in the UK. Reduced intakes of saturated animal fat and cholesterol may explain the lower rates of IHD among vegetarians compared with meat eaters and increasing BMI is associated with increased risk of IHD
Key T.J. *et al.* (1998) (120)	Wrote a review of five prospective studies, which included 76172 men and women and compared with omnivores, mortality from IHD was 24% lower in vegetarians and mortality among vegetarians varied significantly with age at death. RRs were 0.55, 0.69 and 0.92 for deaths from IHD at ages <65, 65–79 and 80–89 years, respectively. Furthermore, mortality from ischemic heart disease was 24% lower in vegetarians than in non-vegetarians, 20% lower in occasional meat eaters, 34% lower in people who ate fish but not meat, and 34% lower in lacto-ovo-vegetarians and 26% lower in vegans. Subsequent measurements of serum cholesterol concentrations in samples of participants in some of the studies have demonstrated lower total serum cholesterol concentrations in the vegetarians than in the non-vegetarians: 0.61 mmol /l lower in the Health Food Shoppers study and 0.43 mmol/L lower in the Oxford
Fraser GE (1999) (121)	Results from a California Seventh-Day Adventists cohort with 34192 subjects showed that RR for fatal IHD in men who ate beef ≥3 times/week was 2.31 and compared with omnivores, lifetime risk of IHD was reduced by 37% in male vegetarians, probably thanks to lower LDL cholesterol concentrations
Huang T. *et al.* (2012) (122)	Meta-analysis of seven prospective cohort studies with 124706 participants showed that vegetarians had a 29% lower mortality from IHD, 16% lower mortality from circulatory diseases and a 12% lower mortality from cerebrovascular disease compared with omnivores
Crowe FL *et al.* (2013) (123)	A total of 44561 men and women (34% vegetarians) living in England and Scotland participated in the European Prospective Investigation into Cancer and Nutrition (EPIC)–Oxford study. Results showed that vegetarians had a 32% lower risk of IHD
Cancers	
Davey GK *et al.* (2003) (34)	Because the mean BMI of vegans is considerably lower than that of non-vegetarians, it may be an important protective factor for lowering cancer risk
Fraser GE (1999) (121)	Data from the Adventist Health Study revealed that non-vegetarians had an increased risk for colorectal and prostate cancer compared with vegetarians, but there were no significant differences in risk of lung, breast, uterine or stomach cancer between the groups after controlling for age, sex and smoking

(continued)

Norat T. *et al* (2005) (124)	478040 men and women from 10 European countries were followed for six years and they examined the relationship between intakes of red and processed meat, poultry and fish, and colorectal cancer risk. As results, colorectal cancer risk was positively associated with intake of red and processed meat and inversely associated with intake of fish, but was not related to poultry intake
Key T.J. *et al.* (2009) (125)	Were studied 61566 British men and women, comprising meat eaters, 'fish eaters' and vegetarians and after 12.2 years there were 3350 incident cancers of which 2204 were among meat eaters, 317 among fish eaters and 829 among vegetarians
Tantamang-Bartley Y. *et al.* (2012) (126)	Examined the association between dietary patterns (non-vegetarians, lacto, pesco, vegan, and semi-vegetarian) and the overall cancer incidence among 69120 participants of the Adventist Health Study-2, with 2939 incident cancer cases. A statistically significant decrease of risk of cancers of the gastrointestinal system was found for vegetarian and lacto-ovo-vegetarian diets, whereas vegan diets showed statistically significant protection for overall cancer incidence in both genders combined and for female-specific cancers In general, it has been observed that colorectal cancer is frequent in Western countries where red meat is frequently consumed, while is rare in less affluent countries where meat intake is low. It is probable that heat-induced mutagens found on the surface of well-done beef meat can cause colon cancer in people with genetic predisposition
Taylor EF *et al.* (2007) (127)	Results from the UK Women's Cohort Study suggested that women who did not eat any meat had a significantly lower risk for breast cancer than women who were regular meat-eaters
Schulz M. *et al.* (2004) (128)	Risk ovarian cancer was significantly lower among fish eaters than among meat eaters. Vegetable but not fruit consumption was found to possibly exhibit beneficial effects on the risk of this cancer, whereas high meat consumption may be associated with an increased risk
Type- 2 diabetes mellitus	
Allen N.E. *et al.* (2002) (129)	Vegans have lower plasma levels of insulin-like growth factor-I than either meat-eaters or lacto-vegetarians
Jenkins DJ *et al.* (2003) (130) Fraser GE (2009) (131) Van Dam RM *et al.* (2002) (132) Salmeron J *et al.* (1997) (133) Trichopoulou A *et al.* (2005) (134) Nothlings U *et al.* (2008) (135)	Epidemiological studies have supported the hypothesis that vegetarian diets protect against Type-2 diabetes mellitus (130), comparing vegetarians with non-vegetarians (131) Participants eating more processed meats in the Health Professionals Follow-up Study had a higher risk of developing diabetes (132) Several recent studies give support to this, including a large US study of women (133), the EPIC Elderly Study in Europe (134) and a large study of patients with diabetes in Europe (135)
Barnard RJ *et al.* (1994) (136) Barnard ND *et al.* (2009) (137)	Clinical dietary studies investigating the impact of vegetarian diets in diabetic patients have shown significant reductions in fasting blood sugar, cholesterol and TAG levels (265-267)
Fraser G (2003) (138) Snowdon DA and Phillips RL (1985) (139)	Prevalence of diabetes is lower in Adventist vegetarians than in Adventist non-vegetarians and part of this advantage is no doubt due to the lower body weights of the vegetarians
Neurodegenerative diseases	
Giem P. *et al.* (1993) (140)	Investigated the relationship between animal product consumption and evidence of dementia in two cohorts, whose participants were enrolled in the Adventist Health Study. The subjects who ate meat (including poultry and fish) were more than twice as likely to become demented as their vegetarian counterparts (RR 2.18) and the discrepancy was further widened (RR 2.99) when past meat consumption was taken into account

Conclusions

As described, the choice of a meat-free diet is due to several motivations and ideologies. The benefits of this lifestyle are well known, while damages, deficiencies and diseases that may arise, are not yet fully known. In fact, many studies focusing on this issue, but the results were often discordant. Therefore, it is important to make more targeted studies to achieve more secure information on a topic so current.

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